(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 277 012 A1**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 88300717.1

(22) Date of filing: 28.01.88

(51) Int. Cl.[4]: F 01 N 3/02
F 01 N 3/28, B 01 D 46/10

(30) Priority: 28.01.87 JP 16124/87 $63-185425

(43) Date of publication of application:
03.08.88 Bulletin 88/31

(84) Designated Contracting States:
BE DE FR GB IT SE

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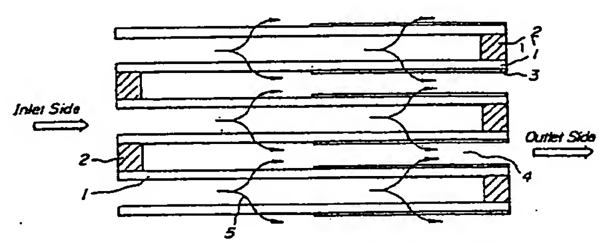
(54) **Ceramic honeycomb filter for purifying exhaust gases.**

(57) A ceramic honeycomb filter for purifying exhaust gases from combustion engines including a ceramic honeycomb structure formed by extruding and having a number of through-passages (4) alternately closed at their ends by ceramic closure members (2). The through-passages are formed by partition walls (1) for capturing fine particles in the exhaust gases which particles accumulate on the partition walls (1). To avoid damage to the filter by overheating when the accumulated particles are burned out in order to regenerate the filter, porous ceramic layers (3) are provided on the partition walls (1) over a distance of 1/10-8/10 of an effective length of the filter from outlet ends of the through-passages (4).

FIG_1



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Description

CERAMIC HONEYCOMB FILTER FOR PURIFYING EXHAUST GASES

This invention relates to a filter for capturing fine particles mainly consisting of carbon in exhaust gases exhausted from combustion engines such as diesel engines and burning the particles to purify the exhaust gases.

A filter for purifying exhaust gases from combustion engines such as diesel engines by removing fine particles mainly consisting of carbon included in the exhaust gases has been known as disclosed for example, United States Patent specification No. 4,364,761 comprising a ceramic honeycomb structure having alternately closed through-apertures. In such a filter, as the fine particles are accumulated in partition walls of the honeycomb structure, pressure losses become large to lower engine performance. Therefore, it is necessary to burn the accumulated fine particles so as to recover the filtering performance.

In conventional honeycomb structures, the partition walls thereof for filtering are usually formed by extruding so that thicknesses of the walls, diameters of pores and porosity of the walls are substantially uniform throughout the structure. The fine particles are therefore accumulated uniformly from inlets to outlets of the partition walls of the honeycomb structures or increasing at the outlet ends.

When the particles are burned to recover the filter, the fine particle layers are progressively burned from the inlet side to the outlet side to restore the filter. In the conventional honeycomb filters adapted to accumulate fine particles thereon, burning heat produced on the inlet side transmits to the outlet side, and further temperature of partition walls on the outlet side rapidly rises owing to burning heat of the fine particles on the outlet sides so that the ceramic filter may melt or cracks may occur due to thermal shock in such a rapid temperature rise.

In order to eliminate such a disadvantage, porous ceramic honeycomb structures are so formed by a corrugate method that the porosity of partition walls decreases from the inlet side to the outlet side as disclosed in Japanese Patent Application Laid-open No.61-129,017. In order to produce such filters having the uneven porosity, however, ceramic green sheets having different porosities must be prepared. What is worse still, such ceramic green sheets of the different porosities make difficult the production of honeycomb structures due to different contraction rates dependent upon their porosities when formed green sheets are fired.

In order to produce filters having various porosities, moreover, various ceramic green sheets must be prepared because the porosities are determined by ceramic green sheets.

It is a primary object of the invention to provide a ceramic honeycomb filter which at least partly eliminates the above described disadvantages of the prior art and which may be easily manufactured and can be recovered by burning without any melting and damage of the filter.

According to the invention, in a ceramic honeycomb filter for purifying exhaust gases, said filter including a ceramic honeycomb structure formed by extruding and having a number of through-passages alternately closed at their ends by ceramic closure members, said through-passages being formed by partition walls for capturing fine particles in the exhaust gases accumulated on the partition walls, the ceramic honeycomb filter comprises porous ceramic layers provided on the partition walls over a distance of 1/10-8/10 of an effective length of said filter from outlet ends of said through-passages for the exhaust gases.

With the above arrangement, the portions of the partition walls provided with the porous ceramic layers become thicker to restrict flows of the exhaust gases passing therethrough so that amounts of fine particles or soot to accumulate thereon will decrease. As a result, when burning the accumulated soot for recovering the filter, heat produced in the partition walls will decrease so that the temperature of the partition walls on the side of the outlet ends becomes lower in conjunction with absorption of the heat in burning the soot by a heat capacity of the porous ceramic layers, thereby preventing any melt and damage of the filter.

Moreover, filters having various porosities can be manufactured simply by coating the porous ceramic layers on the partition walls of the ceramic honeycomb structure formed by extruding according to the invention.

If the porous ceramic layers are made as a catalyst auxiliary carrier of γ-alumina to carry a catalyst such as platinum, carbon monoxide, hydrocarbon and nitrogen oxide in the exhaust gases can be decomposed in addition to the removal of the fine particles in the exhaust gases.

The portions of partition walls provided with the porous ceramic layers over the distance of 1/10-8/10 of the effective length of the filter from the outlet ends of the through-passages corresponds to zones of the partition walls whose temperature heated by the heat produced in burning the accumulated fine particles becomes approximately more than 700°C when the filter is not provided with porous ceramic layers. Therefore, the length of the porous ceramic layers should be determined dependently upon a diameter and a length of the ceramic honeycomb filter and a cell density. However, the porous ceramic layers having a length within the range above described bring about the effects of the invention.

In order that the invention may be more clearly understood, preferred embodiments will be described, by way of example, with reference to the accompanying drawings.

Fig. 1 is a sectional view for explaining one embodiment of the ceramic honeycomb filter for purifying exhaust gases according to the invention; and

Fig. 2 is a graph illustrating relations between lengths of porous ceramic layers and maximum temperatures in filters.

Fig. 1 is a sectional view for explaining one embodiment of the ceramic honeycomb structure for purifying exhaust gases according to the invention. The ceramic honeycomb structure shown in Fig. 1 comprises partition walls 1 forming through-passages 4, closure members 2 for closing ends of the through-passages 4, and porous ceramic layers 3. Arrows 5 denote flows of exhaust gases. In this embodiment, the porous ceramic layers 3 are provided on the partition walls over one half of filter effective lengths on the side of outlets of the exhaust gases. A term of "effective length of the ceramic honeycomb filter" used herein is intended to mean the effective filter length of the partition walls 1 except the closure members 2.

As the ceramic honeycomb constructions used herein, those formed by extruding are preferably used in view of their uniform shapes, diameters of pores, porosities and productivity. Cordierite is preferable as a material of the ceramic honeycomb structure in view of thermal shock-resistance and porosity. Moreover, the through-apertures 4 are preferably hexagonal, square, circular or the like in section. The numbers of the through-apertures are preferably those within a range of 7.7-46.5 cells/cm^2 (50-300 CPI^2) in cell density. Further, thicknesses of the partition walls are preferably 0.25-0.76 mm (10-30 mil).

The closure members 2 are formed by closing predetermined ends of the through-passages of the formed and fired honeycomb structure. The material of the closure members are preferably the same as that of the ceramic honeycomb structure.

The porous ceramic layers 3 are provided on the partition walls 1 on either or both the inlet and outlet sides over the predetermined length above described from the ends on the outlet side. The porous ceramic layers 3 may also be used as catalyst auxiliary carriers. In this case, the catalyst auxiliary carriers are made of γ-alumina or the like to carry a catalyst such as platinum so as to form catalyst carrier layers. With this arrangement, the exhaust gases including fine particles can be purified, while carbon monoxide, hydrocarbon and nitrogen oxide can be oxidized or reduced. Moreover, accumulated soot can be continuously burned by lowering catch fire point of the soot.

The material of the porous ceramic layers 3 is preferably a ceramic material in view of heat-resistance and a predetermined porosity and more preferably the same material as the partition walls because of no difference in heat expansion coefficient.

The thickness of the porous ceramic layers 3 can be selected dependently upon the thickness and porosity of the partition walls and the material and porosity of the porous ceramic layers 3. The thickness of the porous ceramic layers 3 may be uniform or progressively increased from the inlet side to the outlet side for exhaust gases. However, the porous ceramic layers 3 may be comparatively thick in order to prevent the temperature rise of the partition walls due to the burning heat of the fine particles. For example, with honeycomb structure made of cordierite having 143.8 mm (5.66 inch) diameter, 152.4 mm (6 inch) length, 50% porosity, 31 cells/cm^2 (200 CPI^2) cell density and 0.3 mm (12 mil) partition wall thickness, porous ceramic layers 3 of 400 g is provided on the outlet side over 8/10 of filter effective length to obtain the required effect.

Example

Honeycomb structures made of cordierite of shapes of two kinds as shown in Table 1 were prepared to produce samples Nos. 1-10 and reference examples Nos. 11-13 having porous ceramic layers of the material, lengths and weights as shown in Table 1, and prior art examples Nos. 14 and 15 having no porous ceramic layers. The obtained filters were provided on a diesel engine. Fine particles (soot) mainly consisting of carbon were accumulated on partition walls of the samples, accumulated amounts being shown in Table 1. Thereafter, fine particles on inlet sides of the exhaust gases were burned by a burner to measure the maximum temperatures in the respective filters and to inspect damaged conditions of the filters after burning the soot, results of which are shown in Table 1. Fig. 2 illustrates relations between ratios of lengths of the porous layers from outlet ends to filter effective lengths and the maximum temperatures in the filters.

Table 1

Sample No.		Filter: Shape (mm): Diameter	Filter: Shape (mm): Total length	Filter: Cell structure: Thickness of wall (mm)	Filter: Cell structure: Density ($cell/cm^2$)	Porous layer: Material	Porous layer: Dimension *: Ratio to filter effective length	Porous layer: Dimension *: Length (mm)	Porous layer: Weight (g/cm^3)	Amount of accumulated soot (g)	Maximum tempreature in filter (°C)	Damaged condition of filter
Present invention	1	143.8	152.4	0.3	31	Cordierite	1/10	13	0.14	20	1040	in good order
	2	"	"	"	"	"	2/10	26	"	"	990	"
	3	"	"	"	"	"	4/10	52	"	"	860	"
	4	"	"	"	"	"	6/10	79	"	"	840	"
	5	"	"	"	"	"	8/10	106	"	"	1000	"
	6	"	355.6	0.4	15	"	1/10	34	"	"	1010	in good order
	7	"	"	"	"	"	2/10	67	"	"	860	"
	8	"	"	"	"	"	6/10	201	"	"	680	"
	9	"	"	"	"	"	8/10	268	"	"	990	"
	10	"	152.4	0.3	31	γ-alumina	6/10	79	"	"	850	"
Reference example	11	"	"	"	"	Cordierite	0.5/10	7	"	"	1160	damaged
	12	"	"	"	"	"	9/10	119	"	"	1110	"
	13	"	"	"	"	"	10/10	132	"	"	1140	"
Reference example	14	"	"	"	"	Cordierite	0	0	0	"	1400	melted
	15	"	355.6	0.4	15	"	0	0	0	"	1240	damaged

* The dimensions of porous layers do not include sealed portions.

As can be seen from Table 1 and Fig. 2, the maximum temperatures in the filters Nos. 1-10 provided with the porous ceramic layers having ratios 1/10-8/10 to filter effective lengths are lower than those of the filters

Nos. 14 and 15 having no porous ceramic layers. As a result, the filters Nos. 1-10 do not give rise to any damage and melt. With the filter No. 13 provided with the porous ceramic layer all over the filter, fine particles are uniformly accumulated in the filter so that the filter is likely to be damaged although the maximum temperature in the filter is lower than those in the filter No. 14 having no porous ceramic layer. Moreover, even with the filter No. 10 having the porous ceramic layers of γ-alumina serving also as catalyst auxiliary carriers, the maximum temperature is lower to eliminate the risk of damage.

As can be seen from the above explanation, the ceramic honeycomb filter according to the invention can prevent any damage and melt in burning fine particles accumulated in the filter for recovering the filter by providing porous ceramic layers on partition walls over a predetermined distance from exhaust gas outlet end of the filter.

Claims

1. A ceramic honeycomb filter for purifying exhaust gases, said filter including a ceramic honeycomb structure formed by extruding and having a number of through-passages (4) alternately closed at their ends by ceramic closure members (2), said through-passages being formed by partition walls (1) for capturing fine particles in the exhaust gases, characterized by porous ceramic layers (3) provided on the partition walls over a distance of 1/10-8/10 of an effective length of said filter from the outlet ends of said through-passages for the exhaust gases.

2. A ceramic honeycomb filter according to claim 1, wherein said ceramic honeycomb structure is made of cordierite.

3. A ceramic honeycomb filter according to claim 1 or claim 2, wherein said porous ceramic layers (3) are made of cordierite.

4. A ceramic honeycomb filter according to claim 1 or claim 2 wherein said porous ceramic layers (3) are catalyst carriers for carrying a catalyst.

5. A ceramic honeycomb filter according to claim 4, wherein said catalyst carriers consist at least partly of γ-alumina.

6. A ceramic honeycomb filter according to any one of the preceding claims wherein said porous ceramic layers (3) are provided on surfaces of said partition walls (1) on a side of said outlet ends of said through-passages.

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FIG. 1

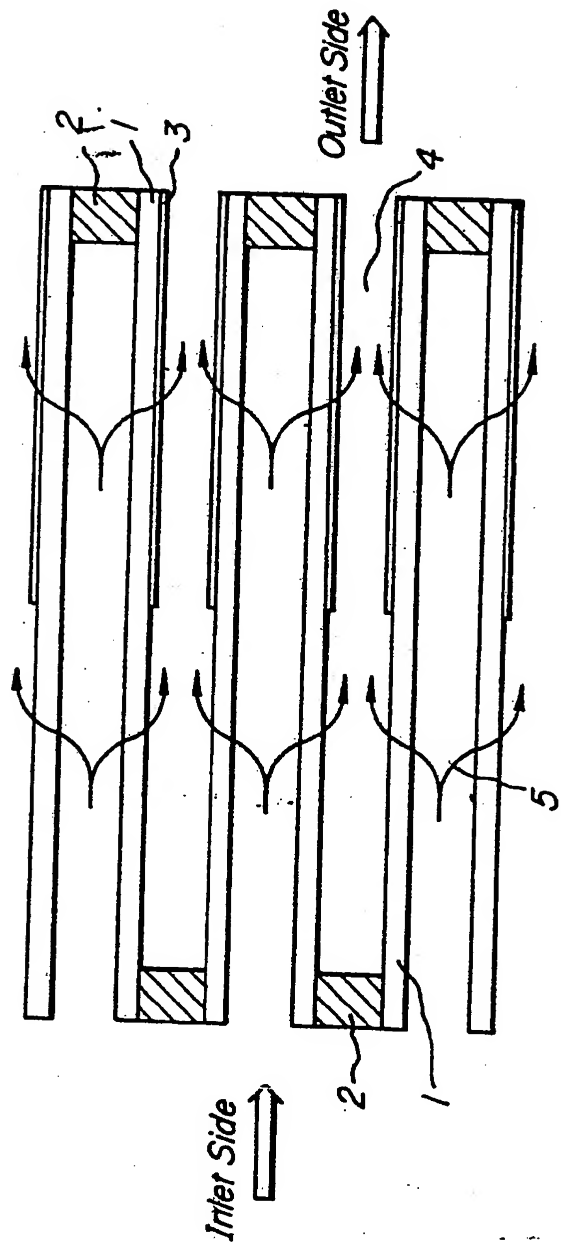
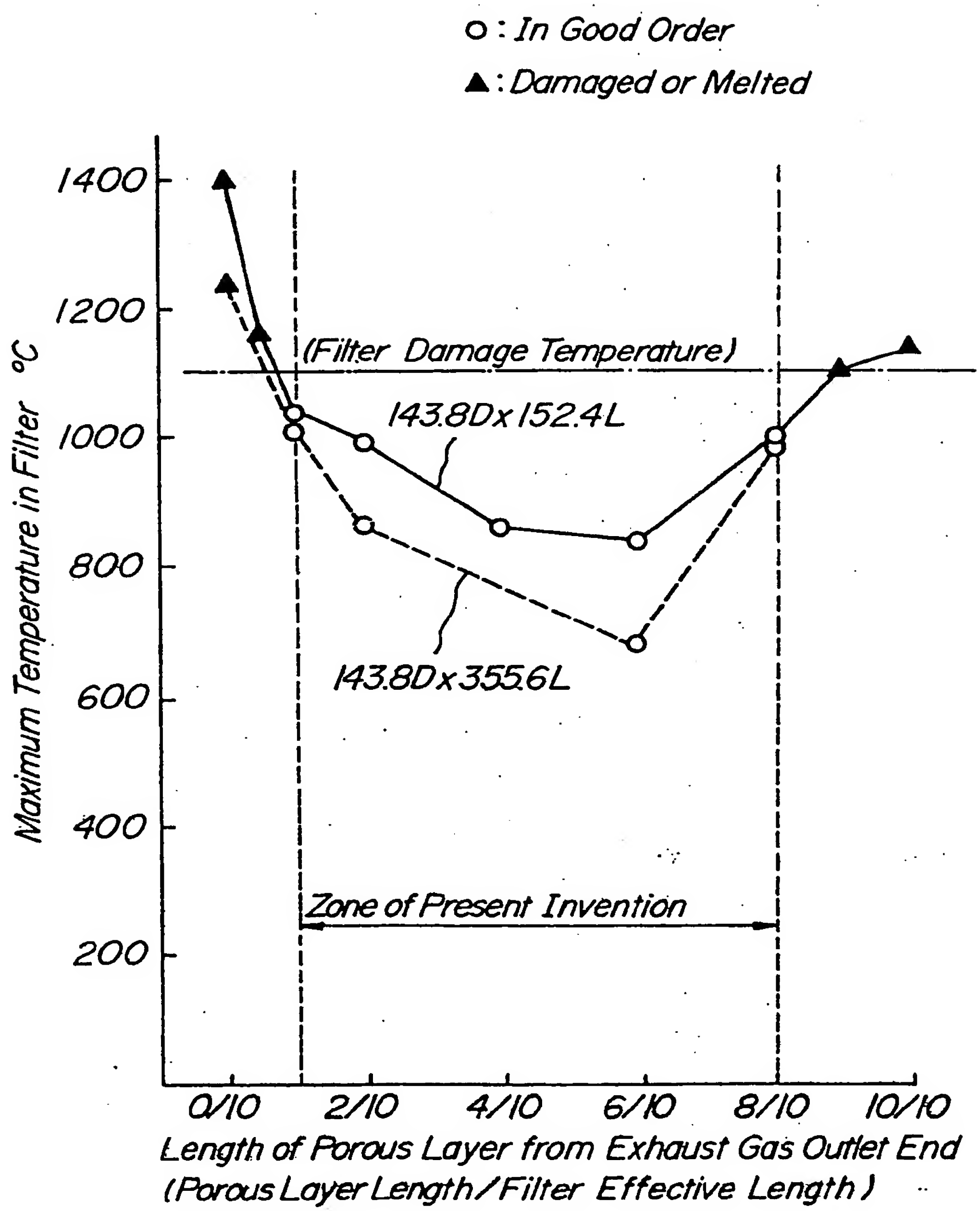


FIG_2


○ : In Good Order
▲ : Damaged or Melted
1400
1200
1000
800
600
400
200
Maximum Temperature in Filter °C
(Filter Damage Temperature)
143.8D x 152.4L
143.8D x 355.6L
Zone of Present Invention
0/10
2/10
4/10
6/10
8/10
10/10
Length of Porous Layer from Exhaust Gas Outlet End
(Porous Layer Length/Filter Effective Length)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 0717

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-4 390 355 (D.C. HAMMOND, Jr.) * Column 2, lines 23-56; column 6, lines 52-58; figure 4; claims 1,2 * ---	1-3	F 01 N 3/02 F 01 N 3/28 B 01 D 46/10
X	EP-A-0 205 755 (MATSUSHITA ELECTRIC INDUSTRIAL CO. LTD) * Page 7, lines 11-17; figures 3a,3b; claims 1,2,5,6 * ---	1	
X	PATENT ABSTRACTS OF JAPAN, vol. 11, no. 196 (M-601)[2643], 24th June 1987; & JP-A-62 20 613 (CATALER KOGYO K.K.) 29-01-1987 * Abstract * ---	1,4,6	
E	PATENT ABSTRACTS OF JAPAN, vol. 6, no. 33 (M-114)[911], 27th February 1982; & JP-A-56 148 607 (ENUKOA K.K.) 18-11-1981 * Abstract * ---	1,4,6	
A	US-A-4 404 007 (TOSHIYUKI TUKAO) -----		TECHNICAL FIELDS SEARCHED (Int. Cl.4) B 01 D 46/00 F 01 N 3/00 C 04 B 38/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10-05-1988	POLESAK, H.F.

CATEGORY OF CITED DOCUMENTS

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